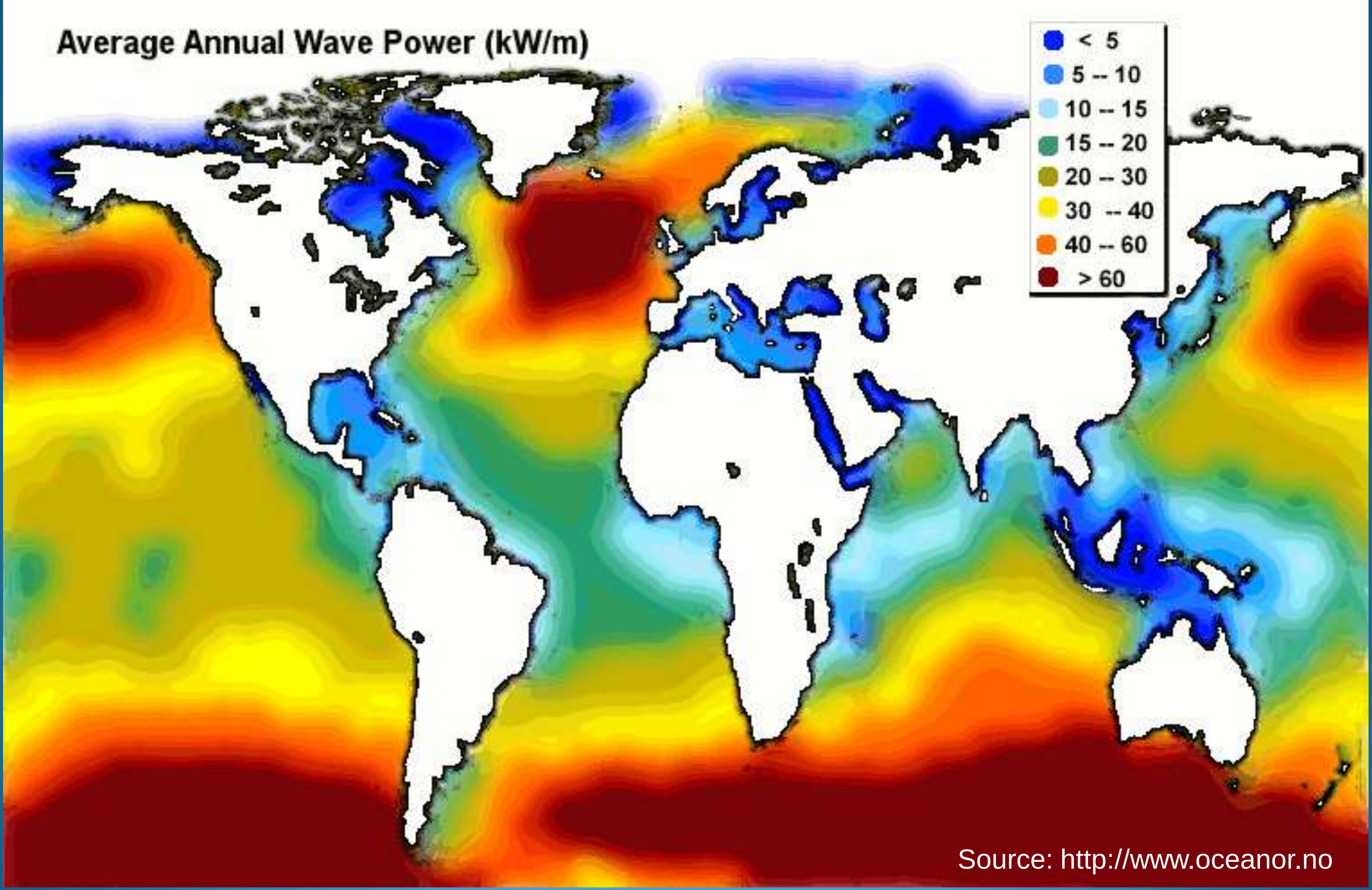
STRAUMEKRAFT

WAVE POWER

Facing the fundamental challenges of wave energy

Vast global resource



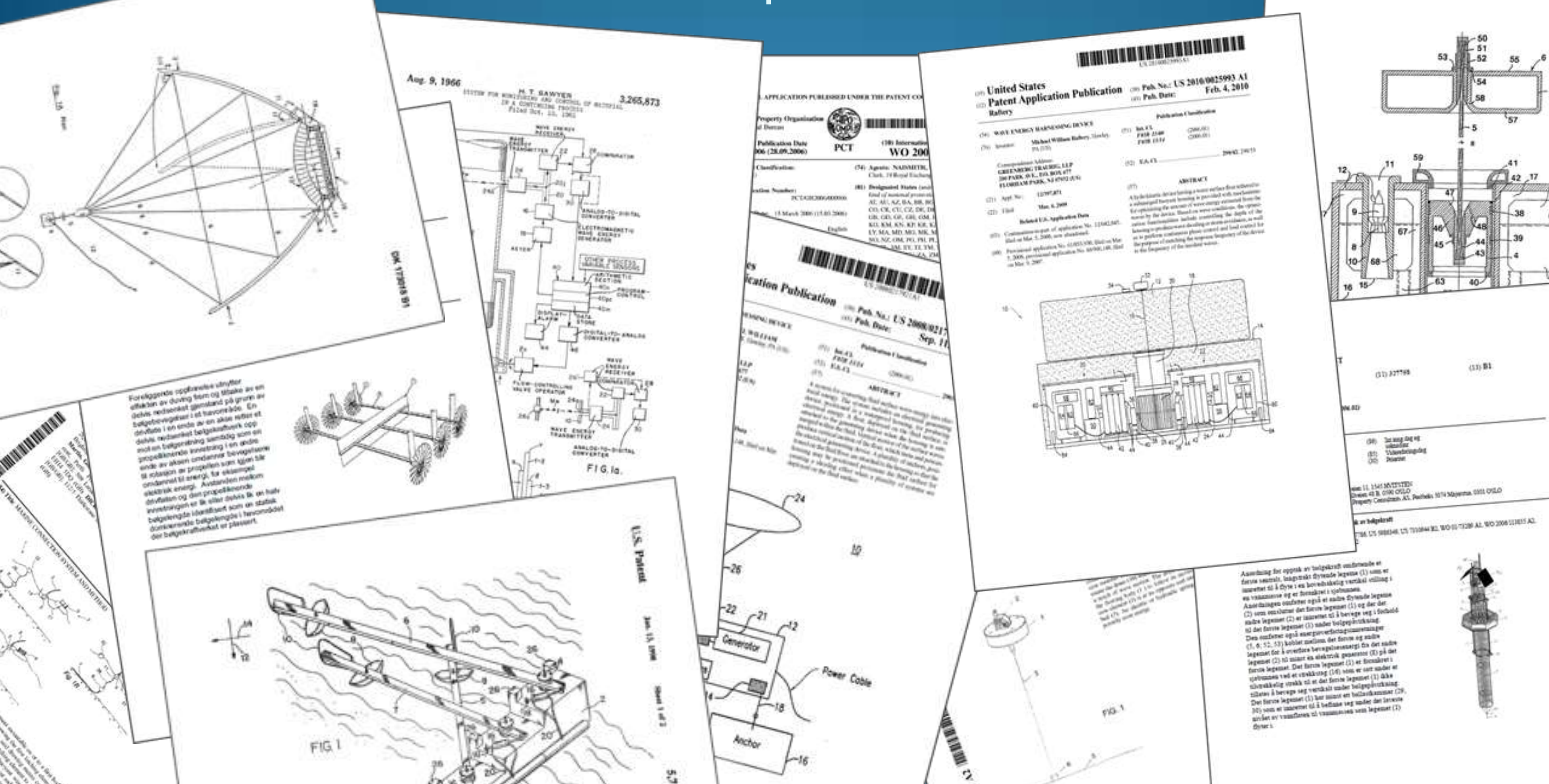
History of wave energy

"It made me positively savage to think of all that power going to waste."

Thomas Alva Edison (1847 – 1931), after spending hours on deck studying the waves, on a cross Atlantic journey in 1889

More than 1000 patents

on wave energy devices have been registered since the first patent in 1799.



Present status:

No commercial wave energy technology has been demonstrated.

Problem:

Energy is too expensive.

Cost of energy formula

$$P = \frac{\left(\frac{r}{(1+r)^y - 1} + r + m\right) \cdot C}{F \cdot I}$$

where:

P	is cost of energy (€/kWh)
C	is production and installation costs (€)
r	is interest rate (%)
m	is annual maintenance costs in % of C
y	is depreciation period (life time) in years
F	is number of full load operating hours per year
I	is rated power (kW)

Factors above fraction line should be minimized.

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Efforts to increase life time

$$P = \frac{\left(\frac{r}{(1+r)^{y}-1} + r + m\right) \cdot C}{F \cdot I}$$

may result in higher production and installation costs.

Efforts to increase full load hours

$$P = \frac{\left(\frac{r}{(1+r)^{y}-1} + r + m\right)\cdot C}{F \cdot I}$$

may result in higher maintenance costs.

Efforts to increase efficiency rates

$$P = \frac{\left(\frac{r}{(1+r)^{y}-1} + r + m\right)\cdot C}{F \cdot I}$$

may result in poor survivability.

Essential points

- Pay attention to all cost-factors, and find the optimum compromise.
- Develop a technology capable of taking care of all factors at the same time.

Why is it so difficult?

1. Extreme waves vs. normal waves
2. Wave motion = slow motion
3. Pulsating energy capture
4. Offshore applicability
5. The mooring dilemma
6. Cost of offshore working hours

1. Extreme vs. normal waves

Wave power pilot plants at Toftestallen in the 1980's

Toftestallen today

1.

The wave energy converter must respond differently to extreme waves than to small and moderate waves.

In small and moderate waves:

“Absorb as much energy as you can!”

In extreme waves:

“Do not do that!”

2. Slow motions

- typical wave motions: ~ 1 m/s
- very large forces

power [kW] = force [kN] · speed [m/s]

Requires heavy machinery. (→ force)

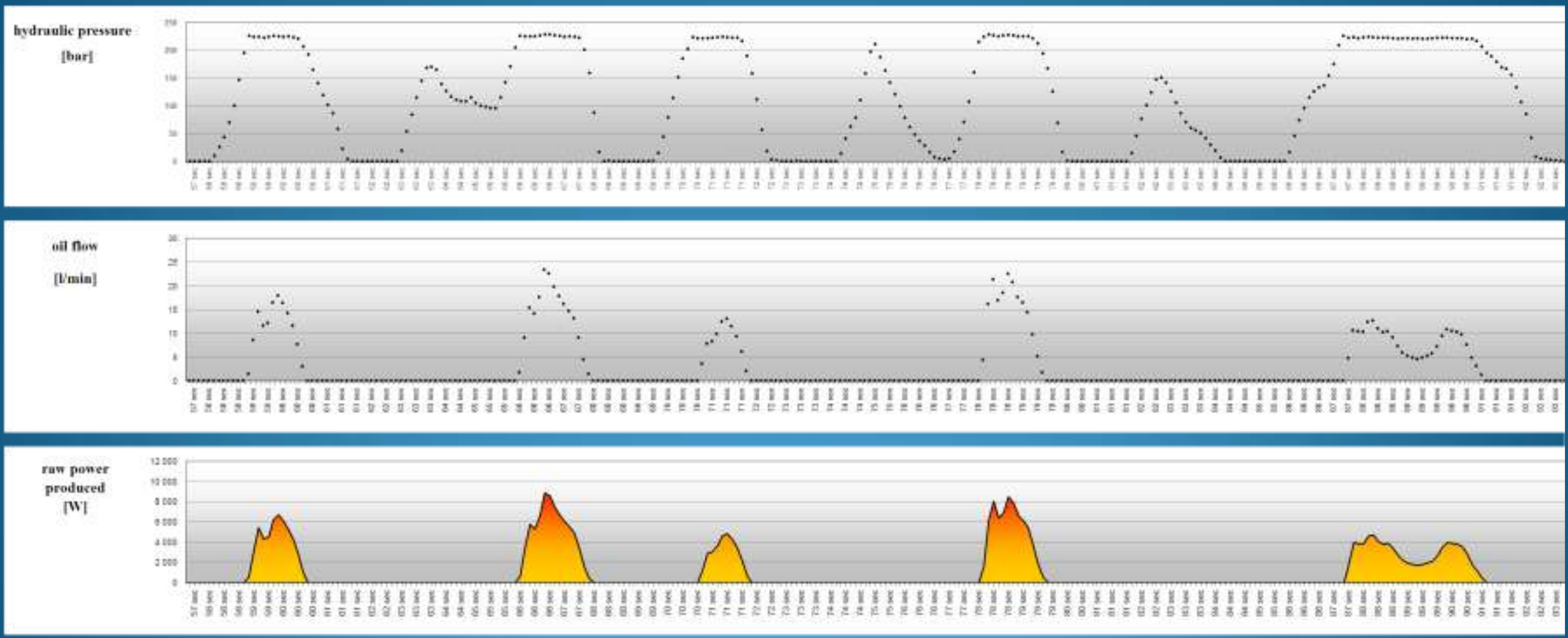
No problem to handle. (→ speed)

2.

The power of the waves should not be geared down, but **up**, to reduce forces on the power-take-off machinery.

Geared-up speeds are not a problem (at least for average waves).

3. Pulsating energy capture

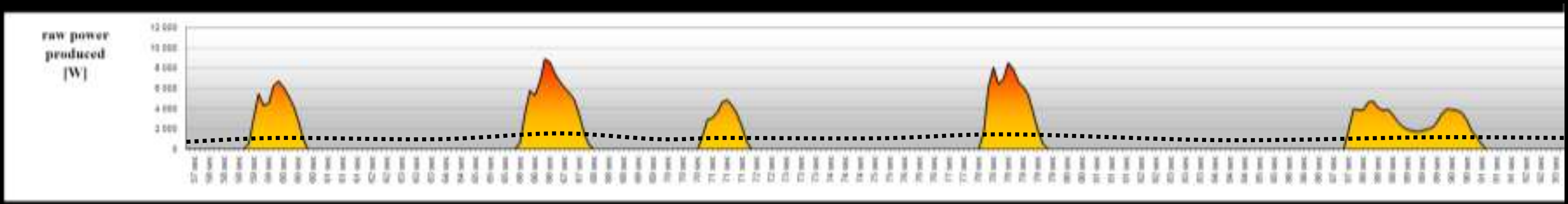


Measurement of raw hydraulic power capture of Straumekraft’s Prototype II, October 2008

3.

The captured “raw” energy calls for being smoothed.

Temporary storage is required.



4. Offshore applicability

- Land based installations will face conflicts. (“Not in my back yard!”)
- Most of the wave energy resource is offshore.

4.

The preferred type of wave energy converter is a floating device

(due to great sea depths of most of the world's oceans).

5. The mooring dilemma

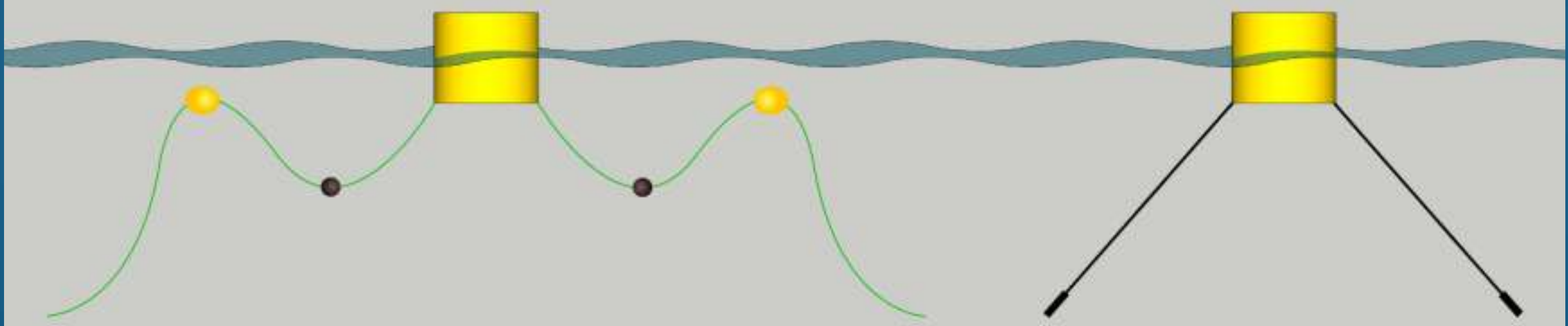
Survivability or power capture ability?

Slack mooring:

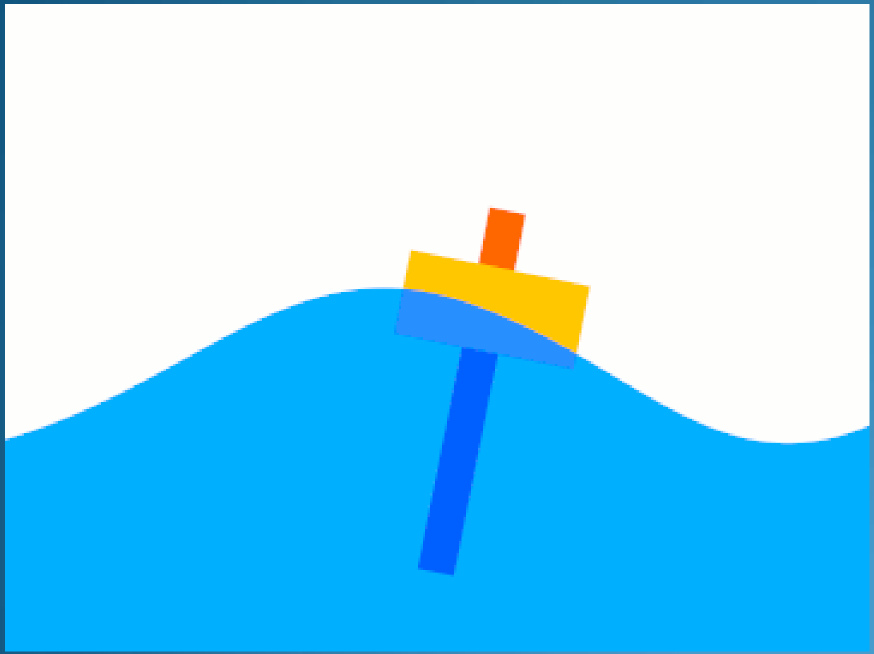
- Poor power capture efficiency in normal waves.
- Good survivability.

Tight mooring:

- Allows for higher power capture efficiency rates.
- Vulnerable in high waves or very expensive.

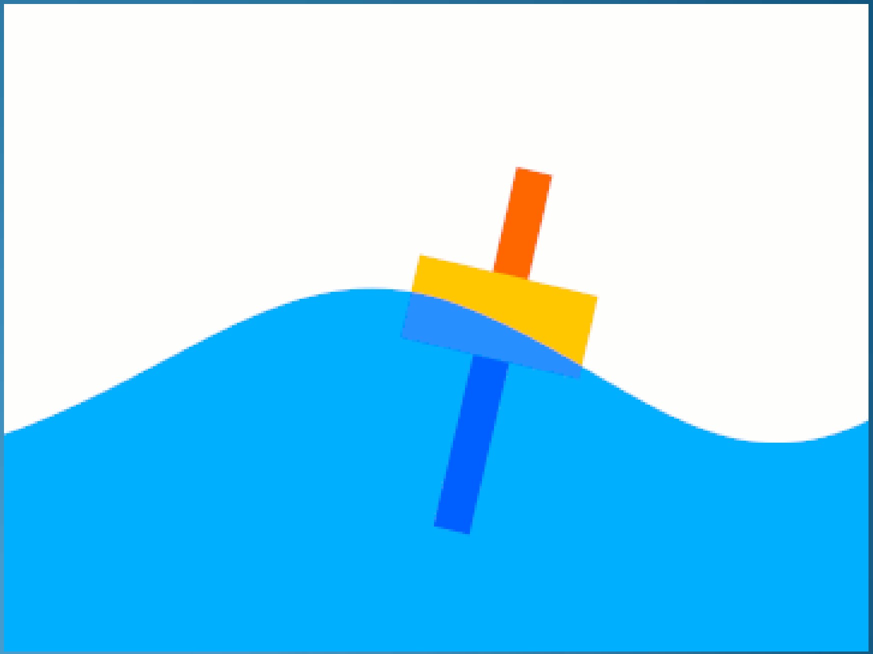


Slack moored wave-bobbing point absorber



Desired motion:

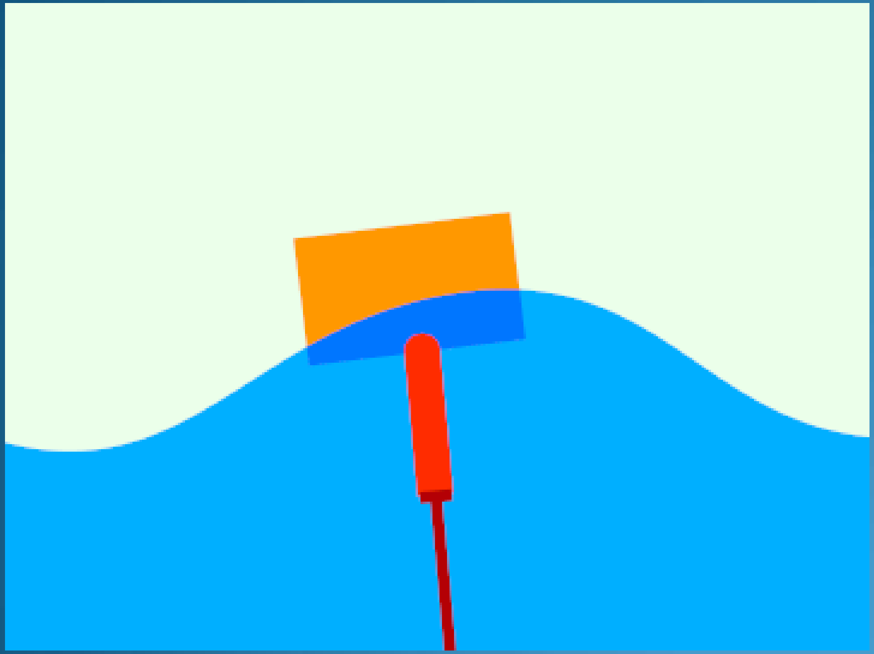
relative movement between parts



Actual tendency:

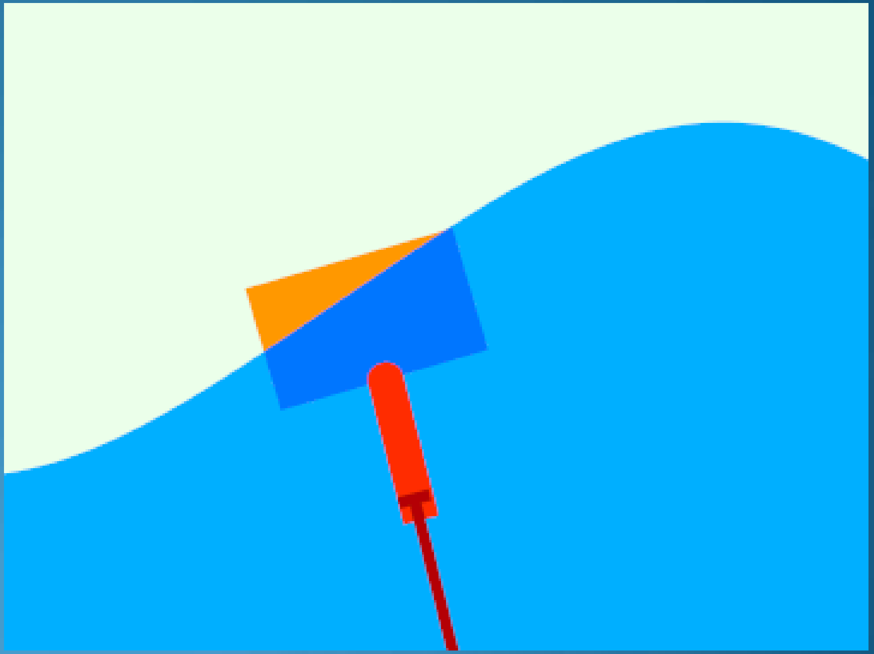
Entire unit moves with the wave.

Tightly moored piston point absorber



In normal waves:

high performance



In high waves:

extreme loads

We should look for a solution which ....

- ✶ avoids the enormous design requirements of a tightly moored system,
- ✶ while still avoiding the reduced energy capture ability of a slack moored system.

6. Cost of installation and maintenance working hours

- Offshore working hours are expensive due to:
  - human risk
  - expensive equipment and vessels
  - remote locations
- Work takes time, due to difficult weather conditions.

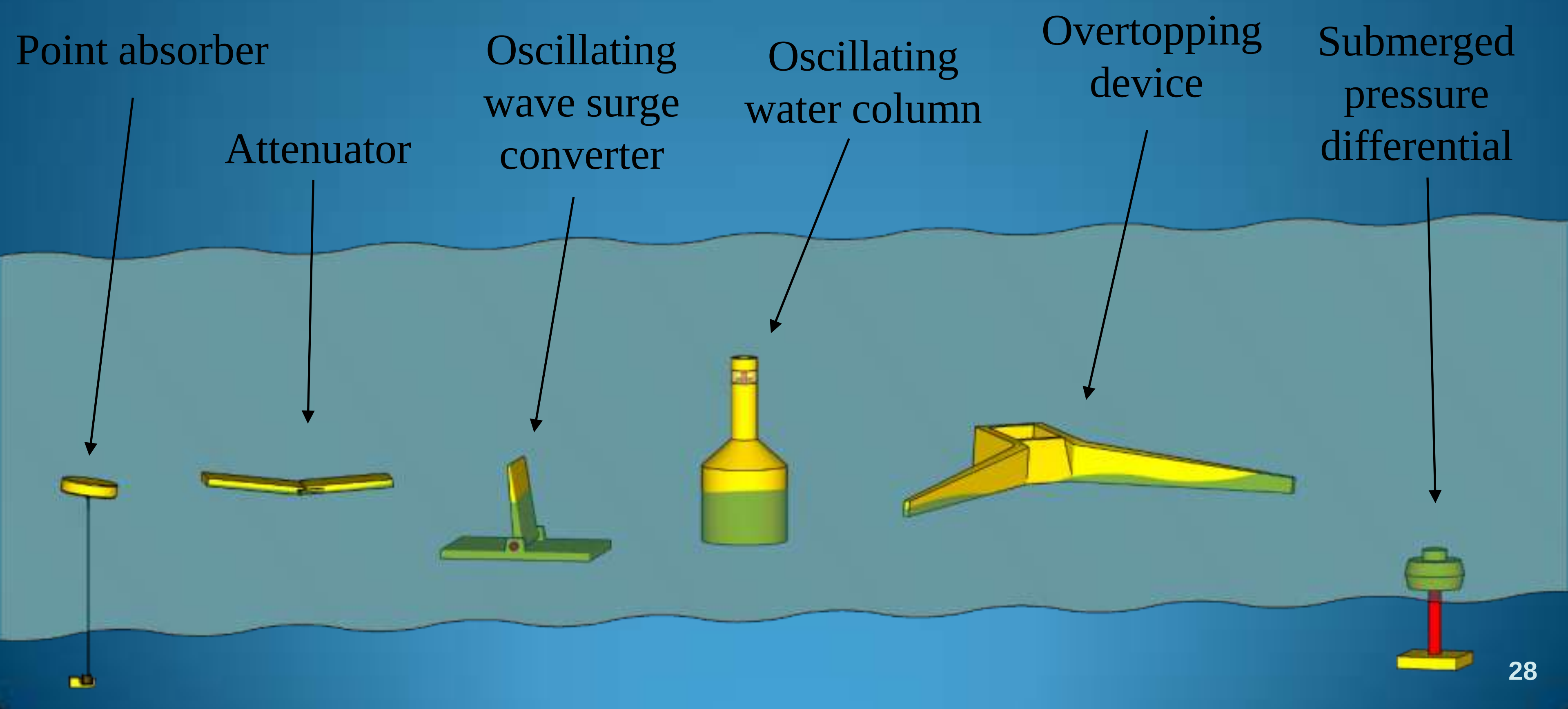
6.

Working time spent onsite should be kept to a minimum.

- ✶ The system must be easy and quick to install.
- ✶ The system must be easy and quick to uninstall (so that it can be taken ashore for major maintenance).

Main categories of wave energy converters

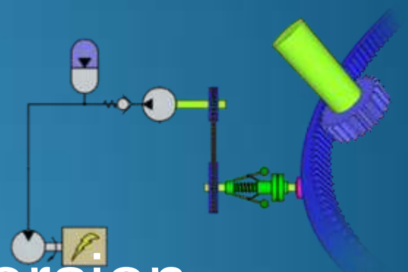
according to the European Marine Energy Centre (www.emec.org.uk)



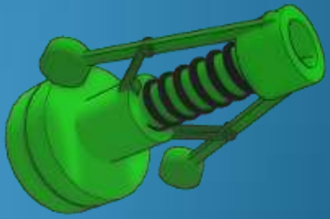
Straumekraft wave power concept characteristics

- point absorber (floating buoy)

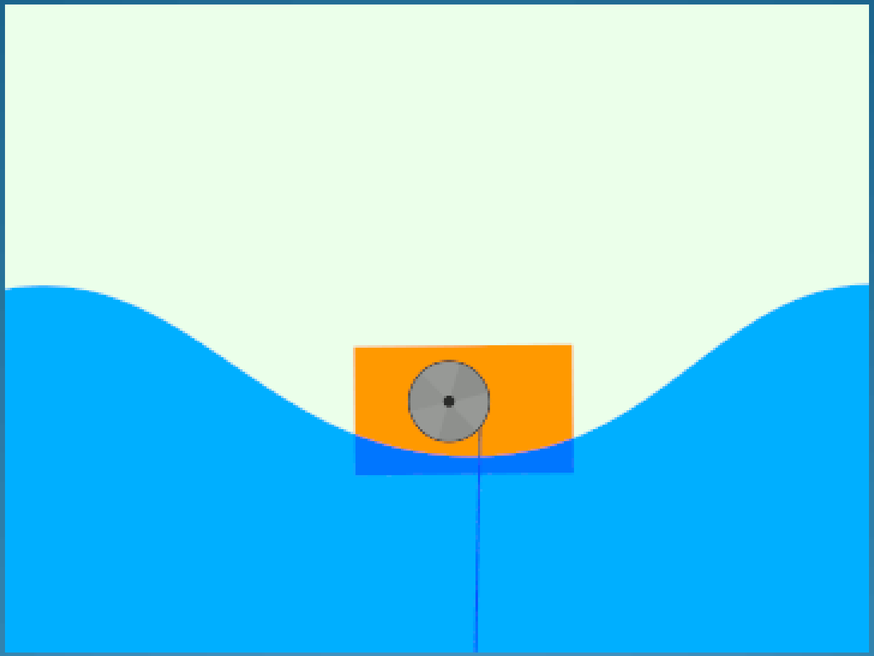
- winch based



- mechanical and hydraulic power conversion
- overload protection (speed-limiter)

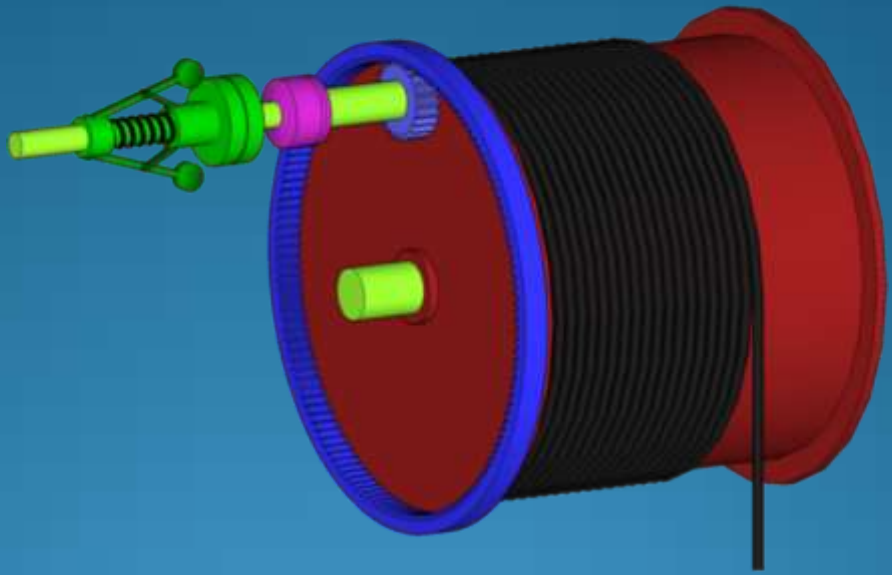


Working principle



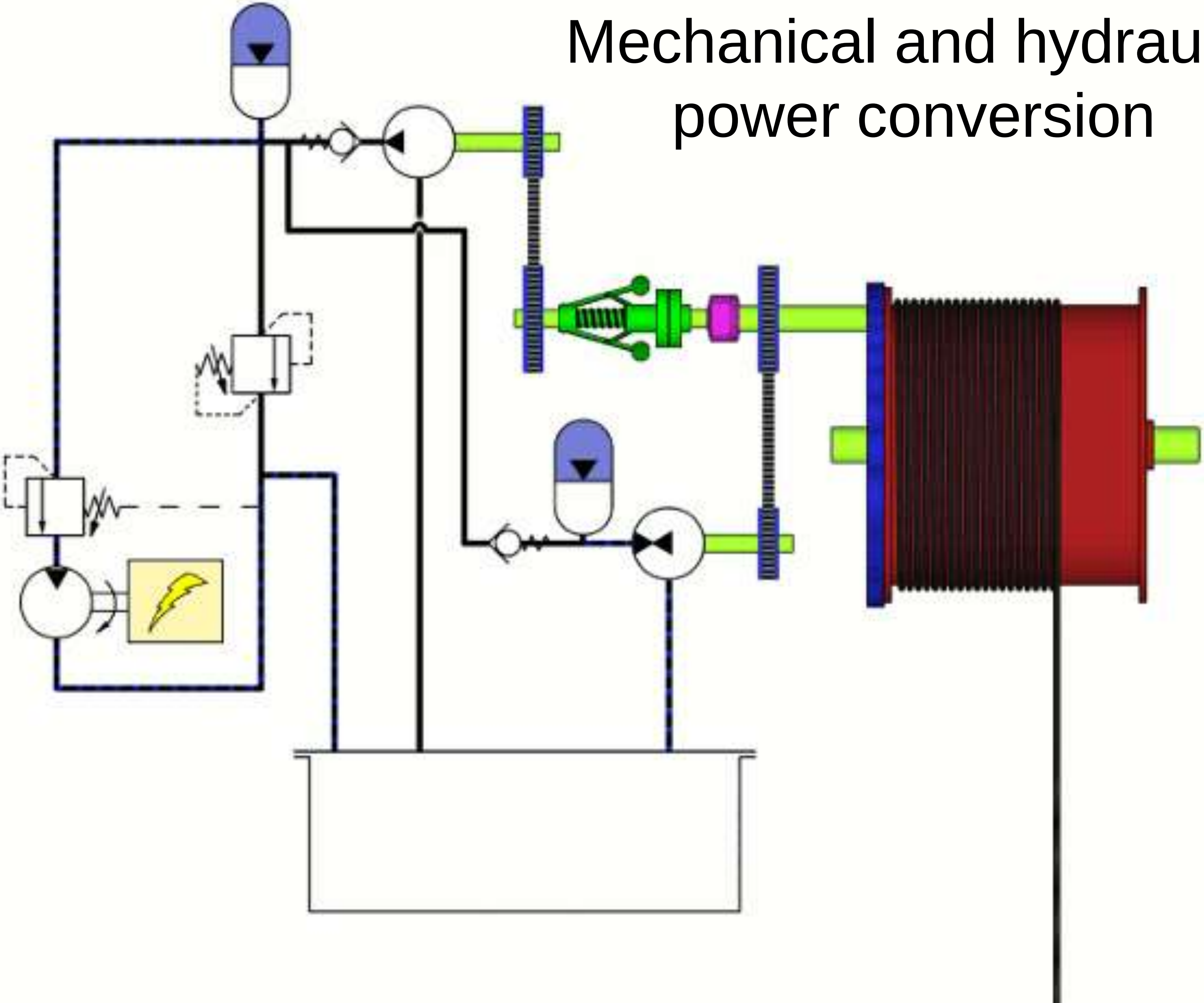
- A floating point absorber is anchored by winch and wire to the seabed (or another fixed reference point).
- When the float is lifted by the wave, energy is captured by the winch drum.

Centrifugal governed clutch = speed limiter



- The rotation is geared **up** and passed through a speed limiter, which is a centrifugal governed slip clutch.
- In high waves, the speed limiter disconnects, to protect the power conversion machinery from excessive speeds and loads.

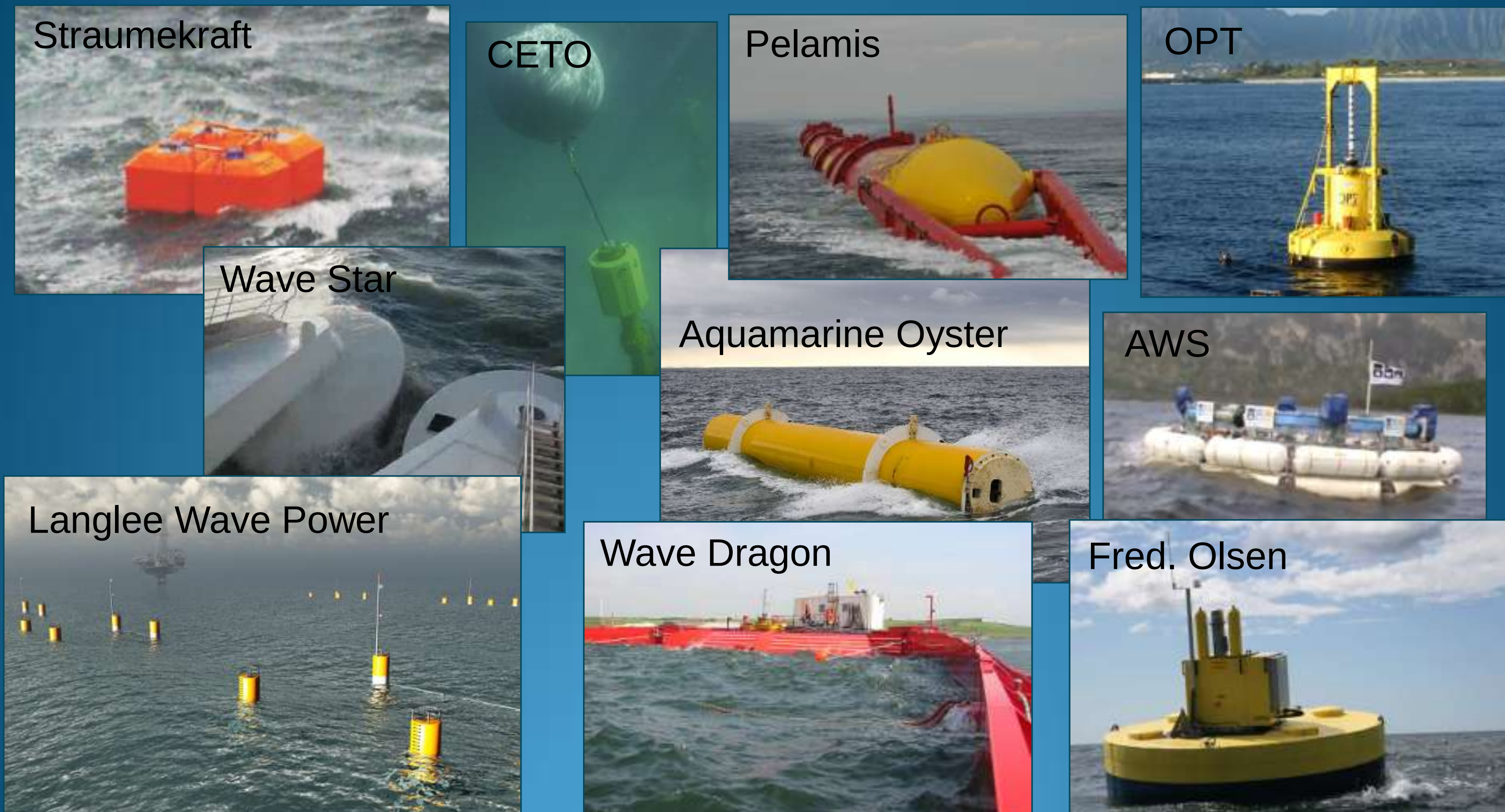
Mechanical and hydraulic power conversion



Straumekraft concept key advantages

- Speed limiter: Provides overload protection in extreme waves
- Gear system: Solves the slow motion speed problem
- Hydraulic accumulator system: Provides smooth energy output
- Offshore applicable
- Dynamic mooring: Solves the mooring dilemma
- Simple to install and uninstall: Yields low costs of operation

Wave energy competitors?



We are cheering for each other!